SPECIAL PROJECT PROGRESS REPORT

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Progress Reports should be 2 to 10 pages
in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2017………………………………………………….……
Project Title:	Diabatic effects in mid-latitude weather systems
Computer Project Account:	SPCHBOJO
Principal Investigator(s):	Maxi Boettcher and Hanna Joos
Affiliation:	ETH Zurich……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Dr. Richard Forbes……….…… ……………………………………………………….……
Start date of the project:	2015………………………………………………..……
Expected end date:	2017………………………………………………..……

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	70000	1622	180000	38582
Data storage capacity	(Gbytes)	3000		5000	

Summary of project objectives

(10 lines max)

The project focusses on the various microphysical heating rates which have an impact on the dynamics of weather systems. With our special model version of the IFS, which outputs all heating rates occurring due to microphysical processes and radiation (provided by Richard Forbes), we are able to investigate in detail the impact of microphysical/radiative processes on the modification of potential vorticity (PV) and thus the impact on dynamics. Via a Lagrangian approach, air parcels which experience a diabatic PV modification are selected, as e.g. in extratropical cyclones, diabatic Rossby-waves, or blocking situations and so, the influence of microphysical processes on the dynamics of these systems can be determined. Furthermore, the IFS is used in order to simulate case studies of weather systems that have been sampled during the aircraft measurement campaign NAWDEX which took place in autumn 2016. The aim is to identify microphysical active regions where model and measurements do not coincide.

Summary of problems encountered (if any)

(20 lines max)

Summary of results of the current year (from July of previous year to June of current year)

In the framework of SPCHBOJO we worked on 4 different projects:

1) Influence of microphysical processes on the upper level flow features associated with an extra-tropical cyclone: In this project we investigated the impact of different parametrizations of cloud microphysical processes and the associated latent heat release in the IFS on the modification of PV in a warm conveyor belt (WCB) and the downstream flow evolution in a case study of an extratropical cyclone. It could be shown that the changes in microphysics lead to a shift in the WCB outflow position and therefore have an influence on the upper level PV pattern and the downstream flow evolution.
This work has been published in October 2016 (Joos and Forbes, 2016, see below).

2) Roman Attinger started his PhD project in September 2016. His focus is on the investigation of the influence of microphysical processes on the formation of positive and negative low and upper level PV anomalies associated with extratropical cyclones and atmospheric blocks in a climatological sense. He therefore applies a Lagrangian technique where backward trajectories are calculated starting from the PV anomalies of interest, like e.g. positive anomalies at the fronts or in the cyclone centre or upper level negative anomalies in atmospheric blocks. Using our special IFS version with detailed output of the temperature tendencies, the contribution of all the microphysical processes to the formation of the selected anomalies are then investigated in detail, following the approach developed by Crezee et al., 2017. It can be shown that below cloud processes like evaporation of rain or sublimation of snow, as well as in-cloud processes like condensation and depositional growth of snow/ice contribute to the formation of low level PV anomalies at fronts. The method will be applied to seasonal simulations in order to extend our knowledge of the link between microphysics and dynamics from case studies to a more climatological perspective.
First results have been presented at the bilateral WCB meeting at ECMWF in May 2017.

3) Elisa Spreitzer started her PhD thesis in January 2017. In her work, Elisa focuses on the impact of changes in the microphysical parametrizations and the related changes in the release of latent heat on the cyclone dynamics and the associated WCBs as well as the downstream flow evolution. In order to investigate this, sensitivity experiments will be performed, where the latent heat release/consumption due to single microphysical processes will be enhanced or decreased based on

the uncertainties in the microphysical parametrizations. In order to assess model performance, the results of the sensitivity experiments will also be compared to measurements conducted in NAWDEX. In a first step, the microphysical characteristics of a WCB associated with cyclone Vladiana, which occurred in October 2016 during the NAWDEX campaign, are determined. It can be shown that the cyclonic and anticyclonic branches of the WCB differ in terms of their microphysical properties. The exact distribution into the two different branches and their impact on the upper level flow is therefore vulnerable for changes in the microphysical parametrizations. First results of this investigation have been shown at the bilateral WCB meeting at ECMWF in May 2017.

4) A case study of a diabatic Rossby wave (DRW) with the associated airstreams which occurred in January 2013 in the North Atlantic has been simulated with the special version of the IFS which allows for hourly output of all microphysical heating rates. Based on this output it is investigated in detail, which microphysical processes occur along the airstreams entering and leaving the DRW and thereby modify the potential vorticity. It can be shown that a strong gradient of latent heating is produced by a mid-tropospheric heating maximum due to in-cloud condensation and convection and by a below-cloud cooling region due to evaporation of rain. This heating gradient and the associated modification of PV ensures for the continuous re-generation and rapid downstream propagation of the DRW's low-level PV anomaly.

This work is in preparation for submission to the Quarterly Journal of the Royal Meteorological Society (see below)

List of publications/reports from the project with complete references

Joos H. and Forbes, R.: Impact of different IFS microphysics on a warm conveyor belt and the downstream flow evolution, Q. J. R. Meteorol. Soc., 142, 2727-2739, doi:10.1002/qj.2863, 2016

Steinfeld, D., Boettcher, M., Joos, H., Forbes, R. and Martius, O.: The Impact of Microphysical Processes on the Potential Vorticity in a Diabatic Rossby Wave, in preparation for the submission to Q. J. R. Meteorol. Soc., 2016

Summary of plans for the continuation of the project

(10 lines max)

Further studies with our special IFS version are planned in the next years (see also the new “Request for a special project 2018-2020”).

The understanding of the importance of the representation of microphysics for extratropical dynamics will be further investigated in different projects. Case study simulations of extratropical cyclones which occurred during the measurement campaign NAWDEX will be performed. This allows to analyse in detail the representation of microphysics in the model and to assess the dynamical relevance (Maxi Böttcher and PhD Elisa Spreitzer). In the PhD project of Daniel Steinfeld, the impact of latent heat release on atmospheric blocks will be investigated by modifying the latent heat release in case study experiments. Roman Attinger will focus in his PhD project on the importance of different microphysical processes for the formation of low and upper level PV anomalies in cyclones and blocks in a climatological framework.